CLAIMS

1. A method for the investigation of a fuel cell system, said fuel cell system having an anode side to which a fuel is supplied in operation and a cathode side to which an oxidizing agent is supplied in operation and comprising at least one fuel cell, each said fuel cell having a an anode, a cathode and a membrane separating said cathode from said anode, said method being adapted to carry out at least one of the following tests:

a) to test whether said fuel cell system is gas-tight at said anode side and/or at said cathode side,

b) to test whether a leakage is present between said anode side and said cathode side,

c) to test a starting behaviour of said fuel cell system,

d) to test an operation of said fuel cell system at low current yield,

each said test being carried out with a mixture of at least one inert gas with at least fuel permissible for the operation of said fuel cell system, said mixture being supplied to said anode side of said fuel cell system and being selected such that a proportion of said fuel present in said mixture lies below a value at which said mixture is flammable in air.

2. A method in accordance with claim 1, wherein nitrogen is selected for said inert gas and hydrogen for said fuel and said mixture contains less than 5.7 vol.-% or mol-% hydrogen in nitrogen.

3. A method in accordance with claim 1, wherein forming gas having at least substantially 95 % N_2 and 5 % H_2 is used as said mixture.

4. A method in accordance with claim 1, wherein it is carried out in an environment with a normal air atmosphere.

5. A method in accordance with claim 1, wherein it is carried out in an environment with normal ventilation.

6. A method in accordance with claim 1, wherein at least one of said tests a), b), c) and d) is carried out during or after manufacture of a vehicle incorporating said fuel cell system as a source of propulsion in order to test operability of said vehicle at a time of manufacture.

7. A method in accordance with claim 1, wherein it is carried out in a workshop after repair of a vehicle containing said fuel cell system.

8. A method in accordance with claim 1, in which said fuel cell system is present as a module, at least one of said tests a), b), c) and d) being carried out during or after the manufacture of said module prior to the installation of said module in one of a vehicle and an installation.

9. A method in accordance with claim 1, at least one of said tests a), b), c) and d) being carried out on a test bed during development of said fuel cell system.

10. A method in accordance with claim 1, wherein a plurality of fuel cells are combined together to form said fuel cell system in the form of a fuel cell stack and at least one of said test a), b), c) and d) is carried out at said fuel cell stack.

11. A method in accordance with claim 1, said fuel cell system comprising at least first and second inlets and at least first and second outlets wherein, during the carrying out of the test a), said mixture is filled at a predetermined test pressure into said fuel cell system through one of said inlets and outlets, with simultaneous, previous or subsequent closing of

further ones of said inlets and said outlets out of which an exit of said mixture could take place and wherein a measurement is made whether said test pressure reduces impermissibly as a function of time.

12. A method in accordance with claim 11 in which said predetermined test pressure lies is approximately twice an intended operating pressure.

13. A method in accordance with claim 1, said fuel cell system comprising at least first and second inlets and at least first and second outlets as well as a plurality of valves at least one of which is associated with each said inlet and outlet, there being lines communicating with said valves, wherein a quantity of said mixture is fed into said fuel cell system, said quantity of said mixture is measured, said valves are switched on or off in accordance with at least one of a predetermined pattern and a predetermined sequence, a measurement is made of a quantity of said mixture emerging from at least some of said lines, a sum is formed of said emerging quantities and is compared with said fed-in quantity to determine any leakages, which appear as a difference value.

14. A method in accordance with claim 13 wherein at least one said valve is a regulatable valve which can be switched on and off.

15. A method in accordance with claim 13, wherein a development in time of said difference value is compared with said predetermined pattern in order to associate any eventually present leakage with a leakage source or a plurality of leakage sources.

16. A method in accordance with claim 1, wherein said fuel cell system is heated to one of an operating temperature and a maximum

permissible excess temperature during the carrying out of any one of said tests.

17. A method in accordance with claim 1, wherein said fuel cell system is heated to one of an operating temperature and a maximum permissible excess temperature prior to the carrying out of any one of said tests.

18. A method in accordance with claim 1, wherein, during development of said fuel cell system, at least one of said tests is carried out as a long term test.

19. A method in accordance with claim 18, said fuel cell system including a plurality of valves which can be switched on and off wherein said long term test includes a plurality of switching on or switching off processes of said valves which can be switched on and off.

20. A method in accordance with claim 19, said fuel cell system further including at least one regulating valve having at least one set value, wherein said long term test also includes changes of said set value.

21. A method in accordance with claim 18, wherein said long term test includes a plurality of heating up and cooling down cycles of said fuel cell system.

22. A method in accordance with claim 1, wherein an association is developed between an electrical power generated by said fuel cell system when supplying a predetermined quantity of said mixture to said fuel cell system and an actual power yield of said fuel cell system when supplying an actual quantity of fuel in operation at at least one preset operating point, with

a check being made whether said electrical power generated during said supply of said predetermined quantity of said mixture corresponds to an expected power yield for said predetermined quantity of said mixture, from which a conclusion is drawn whether, in operation, with supply of said actual quantity of fuel, said actual power yield can be expected at said at least one preset operating point.

23. A method in accordance with claim 1, wherein an association is developed between an electrical power generated by said fuel cell system when supplying a predetermined quantity of said mixture to said fuel cell system and an actual power yield of another fuel cell system of the same kind when supplying an actual quantity of fuel in operation at at least one preset operating point, with a check being made whether said electrical power generated during said supply of said predetermined quantity of said mixture corresponds to an expected power yield for said predetermined quantity of said mixture, from which a conclusion is drawn whether, in operation, with supply of said actual quantity of fuel, said actual power yield can be expected at said at least one preset operating point.

24. A method in accordance with claim 22, wherein said association is examined for various supplied quantities of said mixture and an investigation is made whether corresponding values of said electrical power generated permit a conclusion that said fuel cell system will work in operation at corresponding operating points with different actual quantities of fuel being supplied.

25. A method in accordance with claim 23, wherein said association is examined for various supplied quantities of said mixture and an investigation is made whether corresponding values of said electrical power generated permit a conclusion that said fuel cell system will work in

operation at corresponding operating points with different actual quantities of fuel being supplied.

26. A method in accordance with claim 22, wherein, when testing with the supply of a preset quantity of said mixture, a different manner of operation is consciously selected than in operation with the intended quantity of fuel for the corresponding working point.

27. A method in accordance with claim 26, wherein during testing no recirculation of said mixture is effected at said anode side but during operation with the intended quantity of fuel recirculation takes place.

28. A method in accordance with claim 23, wherein, when testing with the supply of a preset quantity of said mixture, a different manner of operation is consciously selected than in operation with the intended quantity of fuel for the corresponding working point.

29. A method in accordance with claim 28, wherein during testing no recirculation of said mixture is effected at said anode side but during operation with the intended quantity of fuel recirculation takes place.

30. A method in accordance with claim 1, wherein, after a successfully concluded test with said mixture a proportion of fuel in said mixture is increased and a renewed test is carried out.

31. A method in accordance with claim 30, wherein said renewed test is carried out to determine whether a higher power yield of the fuel cell system can be achieved with a significantly reduced proportion of inert gas in said mixture.

32. A method in accordance with claim 30, wherein said renewed test is carried out to determine whether a full power yield of said fuel cell system can be achieved with a degenerated mixture without inert gas.

33. A method in accordance with claim1, wherein at least one of a fuel sensor and an inert gas sensor is used in order to determine any leakages of said mixture.

34. Apparatus for the investigation of a fuel cell system, said fuel cell system having an anode side to which a fuel is supplied in operation and a cathode side to which an oxidizing agent is supplied in operation and comprising at least one fuel cell, each said fuel cell having a an anode, a cathode and a membrane separating said cathode from said anode, said apparatus being adapted to carry out at least one of the following tests:

a) to test whether said fuel cell system is gas-tight at said anode side and/or at said cathode side,

b) to test whether a leakage is present between said anode side and said cathode side,

c) to test a starting behaviour of said fuel cell system,

d) to test an operation of said fuel cell system at low current yield,

said apparatus including the following components:

a device which delivers a mixture of at least one inert gas with at least one fuel permissible for the operation of the fuel cell(s),

a connection line which leads from this device to an inlet at said anode side of the fuel cell(s), and

a device which determines whether said mixture escapes in an impermissible manner.

35. An apparatus in accordance with claim 34, wherein said device for the delivery of said mixture is adapted for the delivery of a mixture of nitrogen for said inert gas and hydrogen for said fuel and said mixture contains less than 5.7 vol.-% or mol-% hydrogen in the nitrogen.

36. An apparatus in accordance with claim 35, wherein the device is adapted for the delivery of forming gas with at least substantially 95 % N_2 and 5 % H_2.

37. An apparatus in accordance with claim 34, said fuel cell system comprising at least first and second inlets and at least first and second outlets as well as a plurality of valves at least one of which is associated with each said inlet and outlet, there being lines communicating with said valves, wherein said device which determines whether said mixture escapes from said fuel cell system consists of a control system which closes all inlets and outlets of said fuel cell system simultaneously or in a predetermined sequence and of at least one pressure sensor which examines whether a predetermined filling pressure of said mixture at said anode side of the fuel cell system reduces impermissibly.

38. An apparatus in accordance with claim 34, said fuel cell system comprising at least first and second inlets and at least first and second outlets as well as a plurality of valves at least one of which is associated with each said inlet and outlet, there being lines communicating with said valves, wherein said device which determines whether said mixture escapes from said fuel cell system consists of a control system which closes all inlets and outlets of said fuel cell system simultaneously or in a predetermined sequence and of at least one pressure sensor which examines whether a time dependent pressure plot departs from a predetermined pressure plot profile.

39. An apparatus in accordance with claim 34, wherein a device is provided for one of the measurement and determination of an ingoing mass flow of said mixture fed into said fuel cell system, a control being provided for the actuation of all valves which can be switched on and off in accordance with one of a predetermined pattern and a predetermined sequence, and wherein devices are provided for the measurement of outgoing mass flows emerging from said valves and a device for comparing said ingoing mass flow with said outgoing mass flows in order to determine any difference values which permit a conclusion to be drawn relating to leakages.

40. An apparatus in accordance with claim 34, there being a heating device for the heating up of said fuel cell system to an operating temperature.

41. An apparatus in accordance with claim 34, there being a device which determines at least one predetermined flow of said mixture through said anode side of said fuel cell system, which corresponds to a working point of said fuel cell system with one of pure fuel and another gas mixture, a device for determining an actual electrical power yield of said fuel cell system with said predetermined through-flow of said mixture and an evaluation device to compare said actual electrical power yield of said fuel cell system with at least one of a predetermined value and a range of values associated with an expected power yield at said working point.

42. An apparatus in accordance with claim 41, wherein said device which determines the through-flow is adapted to set a plurality of different through-flows and said evaluation device associates an actual electrical power yield at said different through-flows with expected power yields at corresponding working points.

43. An apparatus in accordance with 34, wherein said device for the delivery of said mixture is designed to set different desired proportions of fuel in said mixture and a control device is provided in order, following successful testing with a first mixture which lies below the ignition limit for the mixture in air, to increase a proportion of fuel and to carry out a renewed test.